Verification Statement

Environmental Technology Evaluation Center's Verification Statement for ThermoEnergy Ammonia Recovery Process

Technology Type: Wastewater Treatment Technology

Application: Treatment of Domestic Wastewater Centrate Effluent

Technology Name: Ammonia Recovery Process (patent protected)

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The EPA has created the ETV program to facilitate the deployment of innovative environmental technologies through performance verification and information dissemination. The goal of the EvTEC and ETV Programs is to enhance environmental protection by substantially accelerating the acceptance and use of innovative, improved, and more cost-effective technologies. The EvTEC and ETV Programs are intended to assist and inform those individuals in need of credible data for the design, distribution, permitting, and purchase of environmental technologies. This Verification Statement provides a summary of the performance results for the ThermoEnergy Corporation's Ammonia Recovery Process.

Program Operation

The CERF EvTEC Program, in partnership with a panel of experts, i.e., a unique EvTEC Technical Evaluation Panel, and recognized testing organizations, objectively and systematically documents the performance of commercial-ready technologies. Together, with the full participation of the technology developer, they develop plans, conduct tests, collect and analyze data, and report findings. Verifications are conducted according to a rigorous workplan and established protocols for quality assurance. CERF's EvTEC Program acts as an objective third-party evaluation service. Where existing data are used, the data must have been collected by independent third-party sources using acceptable quality assurance protocols. The EPA's ETV Program, through the National Risk Management Research Laboratory (NRMRL), has partnered with the CERF, under an ETV Independent Pilot Project, to verify the performance of environmental technologies.

Technology Description

The technology treatment process is called the Ammonia Recovery Process (ARP) and it is designed to take advantage of the high concentration of ammonia that exists in the centrate obtained by centrifuging an anaerobically digested sludge. ARP removes the ammonia and recycles it into an agricultural fertilizer. The centrate from an anaerobically digested sludge typically contains 20-40% of the total nitrogen load in a wastewater plant.

The ARP is a reversible chemisorption ion exchange. Theoretically, the ARP first concentrates the ammonia from approximately 1,000 parts per million (ppm) in centrate to approximately 15,000 ppm in the regeneration solution by use of a specially prepared ion exchange resin. A solution of zinc sulfate and sulfuric acid are used to regenerate the exchange column. The ammonia-laden spent regeneration solution is further concentrated with an evaporator to approximately 60,000 ppm ammonia. This concentrated solution is then cooled until zinc ammonium sulfate crystals form. The crystals are collected and roasted to drive off ammonia. The resultant ammonia gas is recovered in a packed-bed scrubber where ammonium sulfate forms. The recovered ammonium sulfate crystals are then dried and bagged for use as fertilizer. The zinc sulfate crystals remaining in the roaster are recirculated and used to prepare fresh column regeneration solution (see Figure VS-1).

Evaluation Description

The primary objective of the evaluation of ThermoEnergy's ARP was to perform well-defined field and laboratory tests to provide data on ThermoEnergy ARP's performance. The data as summarized within this Evaluation Report are being made available for distribution to federal, state, and local environmental regulators and to the wastewater treatment community. The goal of this report is to provide potential users and purchasers of the ThermoEnergy ARP with this information so that they can make informed decisions about using ARP at their local treatment works.

At the outset of the project, the Technical Evaluation Panel members developed a list of questions regarding the ARP technology. From this list, several primary objectives were established to test the technology. Accordingly, the ThermoEnergy ARP was evaluated by EvTEC and its technology evaluation process to determine:

- The reduction of centrate ammonia concentrations through the treatment process;
- Process implementation, including ease of operation and maintainability;
- Short-term effectiveness;
- Long-term effectiveness (where possible); and,
- Cost (capital, operation, and maintenance)

In addition, the following issues and questions specifically raised by the EvTEC Evaluation Panel were addressed during the evaluation testing:

- The effect of iron on the resin used in the ARP process;
- The maximum (allowable) solids concentrations influent to the ARP process;
- Soluble zinc concentrations in the effluent from the ARP process
- The effects of polymer use in the dewatering centrifuges upstream of the ARP process;
- Crystal growth and dusting;
- Potential for biofouling of ammonium sulfate crystals;
- The effect of contaminants on the ARP resin and in the crystallization streams; and,
- Struvite formation.

Verification of Performance

ThermoEnergy Environmental Corporation, a joint venture of Foster Wheeler Environmental Corporation (FWENC) and ThermoEnergy Corporation; in association with Battelle Memorial Institute, has developed an alternative process for the recovery of ammonia from wastewater processing streams. The treatment process, called the Ammonia Recovery Process (ARP), is designed to remove/reduce the ammonia-nitrogen load in the waste stream of a municipal sewage treatment plant and to recycle the recovered product into an ammonium salt that can be used as an agricultural fertilizer. A pilot scale ARP treatment facility was constructed and tested at the Oakwood Beach Water Pollution Control Plant (WPCP) in Staten Island, New York, from September through December of 1998.

While operating for a 3-month period (September to December 1998) using the normally produced centrate from the WPCP, the EvTEC evaluation demonstrated that the ARP process was capable of removing ammonia with efficiencies ranging from 75 - 99+ %. For the purposes of this evaluation, the ARP system was run in a batch-mode operation, while the full-scale version would operate under a continuous-mode. EvTEC utilized the services of ACCUTEST®, Dayton, New Jersey to perform verification analytical services.

The ARP is a reversible chemisorption ion exchange. During the EvTEC evaluation, FWENC completed forty-eight (48) processing runs removing ammonia from 25,200 gallons (95,382 liters) of centrate. EvTEC's contracted laboratory, ACCUTEST®, sampled 16 of the forty-eight processing runs. The plant processed the centrate under normal day-to-day conditions at the WPCP, and no special operational considerations were given to the centrifuge operation to accommodate the ARP pilot plant. The Oakwood WPCP was operated in exactly the way it would have been had the ARP technology not been in place. The system performed at high ammonia removal efficiencies even after ferric chloride and polymer-poisoning events, i.e., the ARP resin was regenerated and the system was brought back online. The pilot plant was subject to weather extremes from 90°F (32°C) days in September to 25°F (-4°C) days in December.

ThermoEnergy and FWENC provided the crystal yield data for this EvTEC evaluation. FWENC was able to produce approximately 162.1 lb (73.5 kg) of ammonium-zinc sulfate, $(NH_4)_2SO_4 \bullet ZnSO_4$, crystals from 11,717 gallons (44,350 liters) of centrate flow processed in the ARP. During the pilot plant operations from November 1, 1998 to December 5, 1998, 162.1 lb (73.5 kg) of ammonium-zinc sulfate crystals were produced from 11,717 (44,350 liters) of centrate flow through the ARP. The calculated theoretical value for this flow is 345.7 lb (156.9 kg) ammonium-zinc sulfate crystal. The mass balance of the actual yield versus the expected yield is 46.9% (i.e., 162.1 lb/345.7 lb). The actual yield versus the theoretical yield for the ammonium-zinc sulfate crystals produced during three mass balance production runs ranged from 36.8% to 72.5%. The highest yield for these intermediate crystals was achieved during the last mass balance production run. FWENC site operators computed mass balance closure information for ammonia and zinc around the ARP resin columns and around the crystallization process. The results of these closures are listed in this report as supplemental information in Sections 3.1 and 3.6. Further information on these results can be obtained from ThermoEnergy Corporation.

FWENC had additional off-site testing performed on the evaporation and crystallization efficiencies for the ammonium zinc sulfate produced from the ARP system. During the testing at Oakwood, FWENC shipped a 55-gallon drum of processed centrate regeneration solution to Ionics Resources Conservation Company, Bellevue, Washington. The results of this bench scale testing are available through FWENC and ThermoEnergy Corporation.

Throughout the EvTEC evaluation, the final crystallization process was hampered by the pilot plant scrubber unit. The scrubber unit delivered to the site was not the unit intended for the study and because of this difficulty the final step in producing the ammonium sulfate crystals was not instituted until the last week of operation. According to FWENC data, approximately 20 lb of ammonium sulfate crystals were produced from intermediate crystals in the last two mass balance processing runs.

Based on computer modeling of large scale commercial systems and on the data generated during the pilot study performed at the Oakwood Beach WPCP, FWENC estimates that the total cost to treat ammonia laden wastes at the concentrations found in centrate to be between 3 and 6 cents per gallon on a privatized basis. In determining the costs, no credit was taken for potential resale value

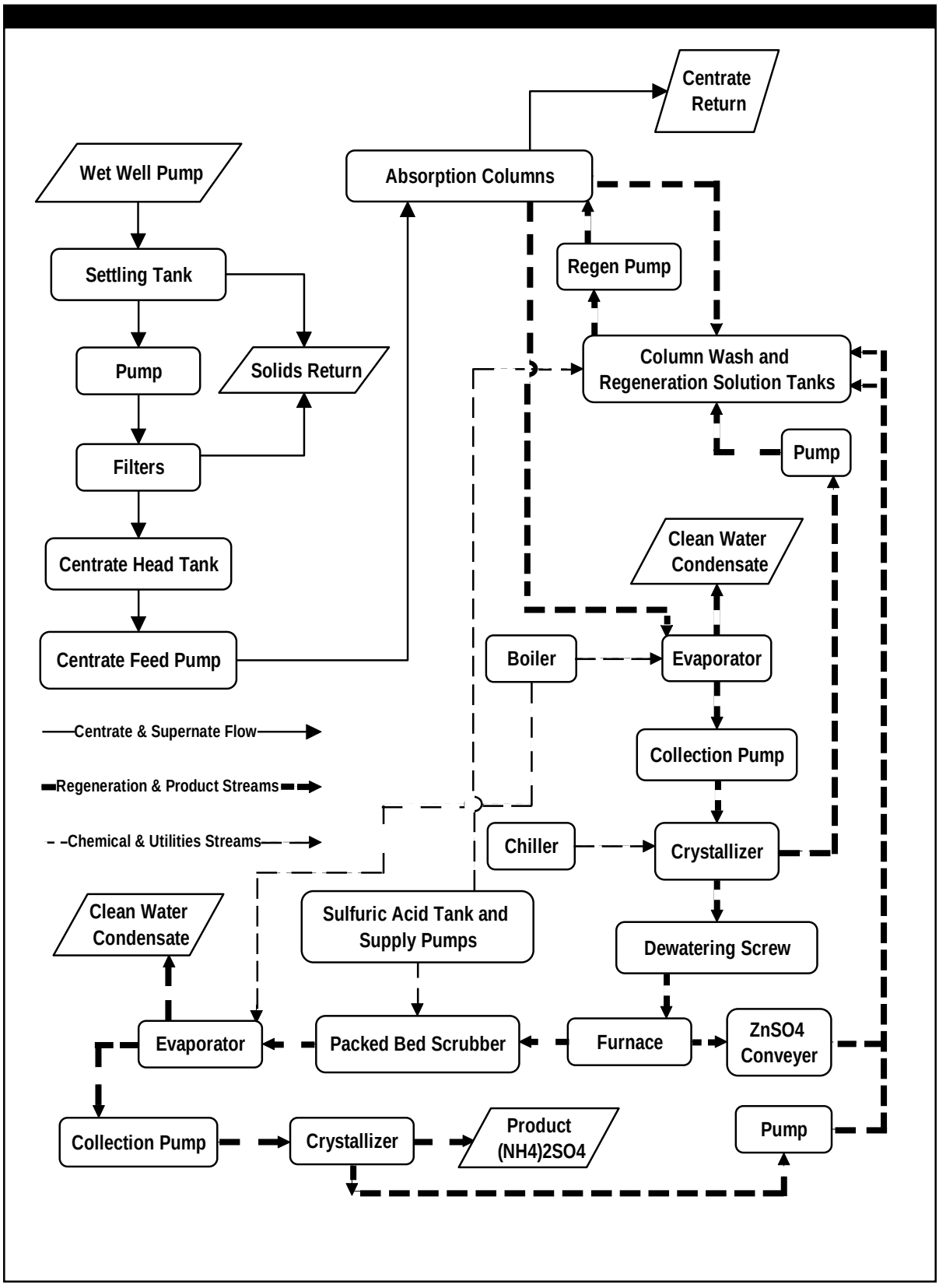

Figure VS 1. Ammonia Recovery Process Schematic

of the fertilizer produced by the ARP. The cost will vary with, and be dependent upon throughput. All scale-up cost information was provided with assistance from ThermoEnergy Corporation and Foster Wheeler Environmental Corporation. These cost values were not verified by EvTEC or its evaluation process.

The information contained in this report represents data that were collected over a 3-month pilot study. As with all new technologies, long term operational data will be obtained through full-scale implementation of the ARP system, however these future testing results are beyond the scope of this evaluation.

Original Signed By

William Kirksey Date
Director, EvTEC Program

Availability of Verification Statement and Report

Copies of the public Verification Statement and Verification Report for ThermoEnergy's Ammonia Recovery Process are available from the following:

1. US EPA / NSCEP
P.O. Box 42419
Cincinnati, Ohio 45242-2419
Web site: http://www.epa.gov/etv/library.htm *(electronic copy)*

2. Civil Engineering Research Foundation
1015 15th Street, NW
Suite 600
Washington, DC 20005
Web site: http://www.cerf.org/evtec
or http://www.epa.gov/etv (*click on partners)*

3. American Society of Civil Engineers
Publications Office
1801 Alexander Bell Drive
Reston, VA 20191
Web site: http://www.pubs.asce.org/
or http://www.epa.gov/etv (*click on partners)*